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The diagram illustrates a multi-line test system for a telephone exchange. It features a central **MAIN DISTRIBUTION FRAME (MDF)** (10) and an **ELECTRONIC RELAY MATRIX (ERM)** (22). The system is divided into a **LINE-SIDE** and a **DROP-SIDE**.

LINE-SIDE:

- TC TESTER** (2) and **TC SWITCH** (121) are connected to the MDF (10) via lines 243 and 244.
- RTC1 SWITCH** (161) and **RTC1 TESTER** (201) are connected to the MDF (10) via lines 122 and 123.
- RTC2 SWITCH** (162) and **RTC2 TESTER** (202) are connected to the MDF (10) via lines 123 and 124.
- RTC3 SWITCH** (163) and **RTC3 TESTER** (203) are connected to the MDF (10) via lines 124 and 123.

DROP-SIDE:

- The **ERM** (22) is connected to the MDF (10) via lines 121, 122, 123, 124, 125, 126, 127, and 128.
- The **ERM** (22) is connected to the **TC SWITCH** (121) via lines 121 and 122.
- The **ERM** (22) is connected to the **RTC1 SWITCH** (161) via lines 123 and 124.
- The **ERM** (22) is connected to the **RTC2 SWITCH** (162) via lines 123 and 124.
- The **ERM** (22) is connected to the **RTC3 SWITCH** (163) via lines 124 and 123.

Customers:

- TC CUSTOMER** (62) is connected to the MDF (10) via lines 81, 82, 83, and 84.
- RTC2 CUSTOMER** (63) is connected to the MDF (10) via lines 81, 82, 83, and 84.
- RTC3 CUSTOMER** (64) is connected to the MDF (10) via lines 81, 82, 83, and 84.

An electronic relay matrix (22) is connectable between a plurality of customer telephone lines and a plurality of testers (2, 20₁-20₃). The electronic relay matrix (22) includes a line matrix (80) having a plurality of relay assemblies (82₁-82₅₀). Each relay assembly (82) in a relaxed state connects together the line-side (12) and the drop-side (8) of one of the customer telephone lines. Each relay assembly (82) is adjustable to enable one of the plurality of testers (2, 20₁-20₃) to be connected to the drop-side (8) and/or the line-side (12) of a desired customer telephone line.

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TELEPHONY TESTING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an electronic relay matrix utilized to selectively connect together a telephone line tester and a customer telephone line.

2. Description of the Prior Art

Until recently, telephone companies (TCs) have enjoyed a monopoly in local exchange carrier markets. Accordingly, in the event of trouble with their telephone service, a customer would notify their TC of the trouble and the TC would initiate an automated test of the telephone and equipment of the customer experiencing the trouble. More specifically, as shown in Fig. 1, a TC tester 2 provides test and control signals to a TC switch 4. The control signals cause the TC switch 4 to selectively connect telephony equipment of a customer, e.g., 6₁, to the TC tester 2 through a drop-side 8₁ of a telephone line, a main distribution frame (MDF) 10, a line-side 12₁ of the telephone line, and the TC switch 4. Similarly, a customer 6₂ can be connected to the TC tester 2 through a drop-side 8₂, the MDF 10, a line-side 12₂, and the TC switch 4.

The Telecommunications (TELCO) Act of 1996 requires TCs to lease customer telephone lines, and specifically the drop-sides 8 of customer telephone lines, to rival telephone companies (RTCs). Hence, the TELCO Act breaks up the monopoly enjoyed by the TCs in the local exchange carrier market.

With reference to Fig. 2, to enable an RTC to service the telephony equipment of the customer 6₂, the line-side 12₂ servicing the telephony equipment of the customer 6₂ is disconnected from the TC switch 4 and connected to an RTC switch 16 through an intermediate distribution frame (IDF) 18. Hence, the RTC switch 10 can service the telephony equipment of the customer 6₂ that heretofore was serviced by the TC switch 4.

In the embodiment shown in Fig. 2, the TC switch 4 and the RTC switch 16 are connected to their respective customers 6₁ and 6₂ through the main distribution frame 10. Since the TC switch 4 services only TC customers, i.e., 6₁, the TC tester 2 is not available to test the line-side 12₂, the drop-side 8₂ and the telephony equipment of the RTC customers 6₂. To test the line-side 12₂, the drop-side 8₂ and the telephony equipment of the RTC customer 6₂, the RTC must provide an RTC tester 20 connected to the RTC switch 16.

If the RTC customer 6₂ reports a problem with their telephone service, the RTC initiates testing of the drop-side 8₂, the line-side 12₂ and the telephony equipment of the RTC customer 6₂ with the RTC tester 20. If no problem is found, an assumption is made that the leased TC equipment, i.e., the drop-side 8₂, the line-side 12₂ or the MDF 10, is causing the customer problem and the RTC notifies the TC. Since the line-side 12₂ of the RTC customer 6₂ no longer runs through the TC switch 4, the TC tester 2 is not able to access the line-side 12₂ for automated testing. Hence, a craftsman must be dispatched to run manual tests of the line-side 12₂, the drop-side 8₂ and the telephony equipment of the RTC customer 6₂. If trouble is found, the fault must be located and repaired.

The inability of the TC to automatically test the line-side 12₂, the drop-side 8₂ and the telephony equipment of the RTC customer 6₂ represents a potential for increased time to repair customer problems, increased use of human resources and increased costs due to the increased use of human resources. The potential for this increased cost is of sufficient concern that utility regulations require RTCs to pay TCs for false trouble reports and no-problem-found situations. However, the regulations also provide that TCs can only bill RTCs for false trouble reports or no-problem-found situations if the TC is capable of submitting a test printout to verify the results. However, since the TCs are

unable to use the TC tester 2, automated test printouts are not readily available. The lack of automated test printouts impedes the ability of the TCs to invoice RTCs for false trouble reports and no-problem-found situations.

5 With poor trouble handling procedures, the TCs and the RTCs may experience profit losses and possibly even customer losses.

10 It is therefore an object of the present invention to provide a point of access for testing non-switched customer lines and special service circuits using existing test equipment. It is an object of the present invention to provide an apparatus that enables TCs and RTCs to test telephone lines leased to RTCs utilizing a TC tester or an RTC tester. Still further objects of the
15 present invention will become apparent to those of ordinary skill in the art upon reading and understanding the following detailed description.

SUMMARY OF THE INVENTION

Accordingly, we have invented a test system for
20 testing a first plurality of telephone lines and a second plurality of telephone lines. The test system includes an electronic relay matrix (ERM) connectable between the line-side and the drop-side of each telephone line of the first plurality of telephone lines and connectable between the
25 line-side and the drop-side of each telephone line of the second plurality of telephone lines. A first tester is connected to the ERM via the line-side of each of the first plurality of telephone lines and via a first test path. A second tester is connected to the ERM via the line-side of
30 each of the second plurality of telephone lines and via a second test path. In response to a control signal on one of the first test path and the second test path, the ERM connects to one of the first test path and the second test path at least one of the line-side and the drop-side of a
35 telephone line of one of the first plurality of telephone lines and the second plurality of telephone lines.

In the absence of the control signal, the ERM connects together the line-side and the drop-side of each telephone line of the first plurality of telephone lines and connects together the line-side and the drop-side of
5 each telephone line of the second plurality of telephone lines.

A first switch can be connected between the first tester and the line-sides of the first plurality of telephone lines. The first switch is configured to connect
10 the first tester to the line-side of one of the first plurality of telephone lines. A second switch can be connected between the second tester and the line-sides of the second plurality of telephone lines. The second switch is configured to connect the second tester to the line-
15 sides of one of the second plurality of telephone lines.

A third switch can be connected between a third tester and the ERM. The third switch is connected to the ERM via line-sides of a third plurality of telephone lines. The third switch is configured to connect the third tester
20 to at least one of the line-sides of the third plurality of telephone lines. An intermediate distribution frame can be connected between the second switch and the ERM and between the third switch and the ERM. The intermediate distribution frame can be utilized to connect each line-
25 side of the second plurality of telephone lines and each line-side of the third plurality of telephone lines to the second tester and the third tester, respectively.

We have also invented an electronic relay matrix (ERM) which is connectable to a plurality of testers and a
30 plurality of telephone lines. Each tester is connectable to the ERM through a test path and through the line-side of at least one of the plurality of telephone lines. The ERM includes a line matrix having a plurality of relay assemblies. Each relay assembly is configured to connect
35 together the line-side and the drop-side of one of the plurality of telephone lines and to receive an address signal. A relay mechanism is connected between the line

matrix and the test paths. A controller is configured to detect a control signal on one of the test paths and to cause the relay mechanism to connect the one test path to the plurality of relay assemblies. The controller causes
5 an address signal to be generated whereby one of the relay assemblies adjusts and connects the one test path to at least one of a line-side and a drop-side of the telephone line connected to the one relay assembly.

The ERM can include a plurality of current
10 detectors, a multi-frequency decoder, a TR reverse switch, a DC detect circuit and an AC detect circuit. Each current detector can be configured to detect the presence of the control signal on one of the test paths and to provide the controller with an indication thereof. The multi-frequency
15 decoder can be configured to decode the control signal on the one of the test paths and to provide to the controller the decoded control signal. The TR reverse switch can be configured to reverse a polarity of a tip-ring pair which comprise the one test path. The DC detect circuit can be
20 configured to detect a DC signal on one of the plurality of telephone lines and to provide to the controller an indication thereof. The AC detect circuit can be configured to detect an AC signal on one of the plurality of telephone lines and to provide the controller with an
25 indication thereof.

Each test path can include a ring lead, a tip lead and a sleeve lead. The plurality of current detectors can include a first plurality of current detectors which are each configured to detect the control signal on one of
30 the tip lead and the ring lead of one of the test paths and to provide to the controller an indication thereof. The plurality of current detectors can also include a second plurality of current detectors each configured to detect the control signal on the sleeve lead of one of the test
35 paths and to provide to the controller an indication thereof.

The relay mechanism can include a first relay, a second relay and third relay. The first relay can be configured to connect the multi-frequency decoder to one of the test paths in response to one of the plurality of
5 current detectors detecting the control signal on the one test path. The second relay can be configured to connect the DC detect circuit and/or the AC detect circuit to the plurality of relay assemblies in response to the controller receiving the decoded control signal. The third relay can
10 be configured to connect the one test path to the plurality of relay assemblies in response to the DC detect circuit and/or the AC detect circuit detecting an absence of a DC signal and/or an AC signal on the telephone line connected to the at least one relay assembly.

15 An address decoder can be connected between the controller and the line matrix. The address decoder can be configured to receive from the controller a signal that causes the address decoder to supply the address signal to the one of the relay assemblies.

20 We have also invented a method of testing a plurality of telephone lines. The method includes detecting an absence of subscriber activity on one of a plurality of telephone lines having its line-side connectable to one tester. In response to detecting the
25 absence of subscriber activity, a test path of the one tester or the test path of another tester is connected to the line-side and/or the drop-side of the one of the plurality of telephone lines.

Lastly, we have invented an apparatus for testing
30 a telephone line. The apparatus includes a decoder which is connected to a controller and which is connectable to a test path. The decoder is configured to decode a control signal on the test path and to provide the decoded control signal to the controller. A line matrix is connected to
35 the controller and is connectable to a plurality of telephone lines each having a line-side and a drop-side. A telephone line detector is connected to the controller

and is connectable to the plurality of telephone lines. A relay mechanism is connected to the controller, the line matrix, the telephone line detector and the test path of the first tester. In response to receiving the decoded control signal, the controller causes the line matrix to select one of the plurality of telephone lines and causes the relay mechanism to connect the telephone line detector to the selected one of the plurality of telephone lines. In response to the telephone line detector detecting an absence of activity on the selected one of the plurality of telephone lines, the controller causes the relay mechanism to connect the test path to at least one of the line-side and the drop-side of the selective one of the plurality of telephone lines.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a prior art connection of a telephone company (TC) tester to a TC switch which services plural customer lines;

Fig. 2 is a block diagram of a prior art TC tester connected to a TC switch which services a TC customer through a main distribution frame and a rival telephone company (RTC) tester connected to an RTC switch which services an RTC customer through the main distribution frame;

Fig. 3 is a block diagram of a TC/RTC switching and testing network connected to a main distribution frame through an electronic relay matrix in accordance with the present invention;

Figs. 4a-4b are block diagrams of internal circuitry of the electronic relay matrix of Fig. 3 including a plurality of relay assemblies;

Fig. 5 is a block diagram of two of the relay assemblies of Fig. 4b; and

Fig. 6 is a block diagram of the network shown in Fig. 3 including a plurality of customers connected to each of the RTC switches and the TC switch.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to Fig. 3, a telephone company (TC) tester 2 is connected to a TC customer 6₁ through a TC switch 4, a line-side 12₁ of a telephone line, an electronic relay matrix (ERM) 22, a main distribution frame (MDF) 10 and a drop-side 8₁ of the telephone line. Connected between the TC tester 2 and the ERM 22 is a line 24₁ which includes a sleeve S1 and a tip-ring pair TR1. The sleeve S1 and the tip-ring pair TR1 are utilized to pass test and control signals between the TC tester 2 and the ERM 22.

A first rival telephone company (RTC₁) tester 20₁ is connected to an RTC₁ customer 6₂ through an RTC₁ switch 16₁, an intermediate distribution frame (IDF) 18, a line-side 12₂ of a telephone line, the ERM 22, the MDF 10 and a drop-side 8₂ of the telephone line. The RTC₁ tester 20₁ is also connected to the ERM 22 by a line 24₂ which includes a sleeve S2 and a tip-ring pair TR2. A second rival telephone company RTC₂ tester 20₂, shown in phantom in Fig. 3, can be connected to an RTC₂ customer 6₃ through an RTC₂ switch 16₂, the IDF 18, a line-side 12₃ of a telephone line, the ERM 22, the MDF 10 and a drop-side 8₃ of the telephone line. Similarly, a third rival telephone company RTC₃ tester 20₃, shown in phantom in Fig. 3, can be connected to an RTC₃ customer 6₄ through an RTC₃ switch 16₃, the IDF 18, a line-side 12₄ of a telephone line, the ERM 22, the MDF 10 and the drop-side 8₄ of the telephone line. The RTC₂ tester 20₂ and the RTC₃ tester 20₃ are also connected to the ERM 22 by lines 24₃ and 24₄ which include sleeves S3 and S4 and tip-ring pairs TR3 and TR4, respectively. The sleeves S2-S4 and the tip-ring pairs TR2-TR4 of lines 24₂-24₄ are utilized to pass test and control signals between the ERM 22 and the RTC testers 20₁-20₃, respectively.

The line-side 12₁ and the line 24₁ define a first test path and a second test path, respectively, between the TC tester 2 and the ERM 22. The first test path is utilized to convey test signals between the TC tester 2 and the TC customer 6₁ via the line-side 12₁ and the drop-side

8₁ of the telephone line of the TC customer 6₁. The second test path is utilized to convey test and control signals between the TC tester 2 and the ERM 22. The control signals conveyed via the line 24₁ cause the ERM 22 to selectively connect to the line 24₁ one of the drop-sides 8₁-8₄ connected to the MDF 10 and/or one of the line-sides 12₁-12₄ connected to the ERM 22. When the line 24₁ is connected to one of the line sides 12₁-12₄ and/or one of the drop-sides 8₁-8₄, the TC tester 2 can supply test signals thereto.

Similarly, the line-sides 12₂-12₄ and the lines 24₂-24₄ define first and second test paths, respectively, between the RTC testers 20₁-20₃ and the RTC customers 6₂-6₄. The first test path is utilized to convey test signals between the RTC testers 20₁-20₃ and the RTC customers 6₂-6₄ via the line-sides 12₂-12₄ and the drop-sides 8₂-8₄, respectively. The second test paths are utilized to convey test and control signals between each RTC tester 20₁-20₃ and the ERM 22. The control signals conveyed via one of the lines 24₂-24₄ cause the ERM 22 to selectively connect to the one of the lines 24₂-24₄, one of the drop-sides 8₁-8₄ connected to the MDF 10 and/or one of the line-sides 12₁-12₄ connected to the ERM 22. When one of the lines 24₂-24₄ is connected to the one of the line-sides 12₁-12₄ and/or the one of the drop-sides 8₁-8₄, the RTC tester 20₁-20₃ connected to the one of the lines 24₂-24₄ can supply test signals thereto. When connected to a line-side and a drop-side, one of the lines 24₁-24₄ is preferably connected to the line-side and the drop-side of the telephone line connected to one customer. However, one of the lines 24₁-24₄ can be cross-connected to the line-side of the telephone line connected to one customer and the drop-side of the telephone line connected to another customer.

With reference to Figs. 4a-4b, and with ongoing reference to Fig. 3, the ERM 22 includes current detectors 40₁-40₄ connected to detect current flowing in the tip leads or the ring leads of the tip-ring pairs TR1-TR4 of lines

24₁-24₄, respectively. A controller 50 is connected to receive from each of the current detectors 40₁-40₄ an output indicative of a current detected thereby. Sleeve current detect/terminations 44₁-44₄ are connected to detect current
5 flowing in the sleeves S1-S4 of lines 24₁-24₄, respectively. The controller 50 is connected to receive from each of the sleeve current detect/terminations 44₁-44₄ an output indicative of the current detected thereby.

A relay 60 is connected between the tip-ring pair
10 TR1 of line 24₁ and a multi-frequency (MF) decoder 62. The controller 50 is connected to an output of the MF decoder 62. A TR reverse switch 64 is connected between the relay 60 and a control output of the controller 50. A relay 66 is connected between the tip-ring pair TR1 and a tip-ring
15 pair TRA. The tip-ring pair TRA are connected to inputs of a DC detect circuit 68 and an AC detect circuit 70. The DC detect circuit 68 and the AC detect circuit 70 have outputs connected to inputs of the controller 50. A relay 72 is connected between tip-ring pairs TR2-TR4 of lines 24₂-24₄
20 and an isolation relay 74. The isolation relay 74 is connected between the relay 72 and a tip-ring pair TRB. The tip-ring pair TRB are connected to inputs of a DC detect circuit 76 and an AC detect circuit 78. The DC detect circuit 76 and the AC detect circuit 78 have outputs
25 connected to inputs of the controller 50. A node between the relay 72 and the isolation relay 74 is connected to the relay 60. Each of the relays 60, 66, 72 and 74 have control inputs connected to relay control outputs of the controller 50. The DC detect circuits 68 and 76 and the AC
30 detect circuits 70 and 78 each include internal relays (not shown) which, under the control of the controller 50, can selectively connect the DC detect circuits 68 and 76 and the AC detect circuits 70 and 78 to the tip-ring pair TRA and the tip-ring pair TRB, respectively.

35 The ERM 22 includes a line matrix 80, shown in Fig. 4b, which has a plurality of relay assemblies 82₁-82₅₀. Each relay assembly 82₁-82₅₀ includes a plurality of relays

each having a plurality of contacts. The relay assemblies 82₁-82₅₀ will be described in greater detail hereinafter.

5 An X-decoder 84 and a Y-decoder 86 each have one or more inputs connected to receive address signals from the controller 50. The address signals received by the X-decoder include a drop-side enable signal, a line-side enable signal, a matrix enable signal and X-address signals. In response to receiving the address signals, the X-decoder 84 supplies to the line matrix 80 an X-DEC
10 signal. Similarly, the address signals received by the Y-decoder 86 include the drop-side enable signal, the line-side enable signal, the matrix enable signal and Y-address signals. In response to receiving the address signals, the Y-decoder 86 supplies to the line matrix 80 a Y-DEC signal.
15 The X-DEC signal and the Y-DEC signal received at the line matrix 80 coact to select one of the relay assemblies 82₁-82₅₀ and to cause the selected one of the relay assemblies 82₁-82₅₀ to adjust and connect the line-side 12 and/or the drop-side 8 of the telephone line connected thereto to a
20 tip-ring pair TR Bus.

The tip-ring pair TR Bus are connected to inputs of each of the relay assemblies 82₁-82₅₀ of the line matrix 80. A relay 88 is connected between the tip-ring pair TRA and the tip-ring pair TR Bus. The relay 88 is also
25 connected between the tip-ring pair TRB and the tip-ring pair TR Bus. The relay 88 has a control input connected to a relay control output of the controller 50. In response to a signal at its control input, the relay 88 selectively connects the tip-ring pair TRA or the tip-ring pair TRB to
30 the tip-ring pair TR Bus. The relays 60, 66, 72, 74 and 88 form a relay mechanism which can selectively connect one of the tip-ring pairs TR1-TR4 of lines 24₁-24₄ to the relay assemblies 82₁-82₅₀ of the line matrix 80 via the tip-ring pair TR Bus.

35 In operation, contacts of the relay assemblies 82₁-82₅₀ are adjusted in response to the TC tester 2 or one of the RTC testers 20₁-20₃ conveying a control signal on the

tip lead of one of the tip-ring pairs TR1-TR4 of lines 24₁-24₄, respectively. In response to the control signal, the controller 50 causes the contacts of one of the relay assemblies 82₁-82₅₀ to adjust and connect the line-side 12 or the drop-side 8 of the telephone line connected to the one of the relay assemblies 82₁-82₅₀ to the tip-ring pair of the line utilized to convey the control signal. This connection enables the TC tester 2 or one of the RTC testers 20₁-20₃ to convey test signals to the line-side 12 or the drop-side 8 of the telephone line connected to the one of the relay assemblies 82₁-82₅₀ through the tip-ring pair of the line utilized to convey the control signal. Alternatively, in response to the control signal, the controller 50 causes the contacts of one of the relay assemblies 82₁-82₅₀ to adjust and bridge connect the tip-ring pair of the line utilized to convey the control signal to the telephone line connected to the one of the relay assemblies 82₁-82₅₀. This bridge connection enables the DC detect circuits 68 or 72 and/or the AC detect circuits 70 or 78 to detect the presence or absence of activity on the telephone line connected to the one of the relay assemblies 82₁-82₅₀. In the absence of a control signal being conveyed on one of the tip-ring pairs TR1-TR4 of the lines 24₁-24₄, the contacts of each relay assembly 82₁-82₅₀ are in a relaxed, normally closed state which forms a pass-through connection between the line-side 12 and the drop-side 8 of the telephone line connected thereto.

More specifically, if the TC tester 2 is utilized to test a selected telephone line, the TC tester 2 supplies to the ERM 22 a control signal on the tip lead of the tip-ring pair TR1 of the line 24₁. The control signal on the tip-ring pair TR1 of the line 24₁ is detected by the current detector 40₁. In response to detecting the control signal, the current detector 40₁ supplies to the controller 50 a signal indicative thereof. In response to the signal from the current detector 40₁, the controller 50 causes the relay 60 to adjust and connect the tip-ring pair TR1 of the line

24₁ to the MF decoder 62 and the TR reverse switch 64. The controller 50 causes the TR reverse switch 64 to reverse the polarity of the tip-ring pair TR1 of the line 24₁. In response to detecting the reversed polarity of the tip-ring pair TR1 of the line 24₁, the TC tester 2 supplies control signals to the tip-ring pair TR1 of the line 24₁. The MF decoder 62 converts the control signals supplied on the tip-ring pair TR1 of the line 24₁ into digital signals usable by the controller 50. The digital signals from the MF decoder 62 are processed by the controller 50 into the address signals that are provided to the X-decoder 84 and the Y-decoder 86. The address signals cause the X-decoder 84 and the Y-decoder 86 to supply to the line matrix 80 the X-DEC signal and the Y-DEC signal. The digital signals from the MF decoder 62 also cause the controller 50 to adjust the relay 88 to connect the tip-ring pair TRA to the tip-ring pair TR Bus and cause the controller 50 to connect the DC detect circuit 68 and the AC detect circuit 70 to the tip-ring pair TRA.

The X-DEC signal and the Y-DEC signal received by the line matrix 80 cause one of the relay assemblies 82₁-82₅₀ to adjust and connect the tip-ring pair TR Bus to (i) a line-side 12 and a drop-side 8 of the selected telephone line in a bridge mode, (ii) the line-side 12 of the selected telephone line or (iii) the drop-side 8 of the selected telephone line. When connected in the bridge mode, the tip-ring pair TR Bus connects the line-side 12 and the drop-side 8 of the selected telephone line to the DC detect circuit 68 and the AC detect circuit 70 via the tip-ring pair TRA. The DC detect circuit 68 and the AC detect circuit 70 detect the presence or absence of a respective DC voltage or an AC voltage, indicative of activity on the selected telephone line, and provide to the controller 50 outputs indicative thereof. In the absence of the DC detect circuit 68 or the AC detect circuit 70 detecting the respective DC voltage or AC voltage on the selected telephone line, the controller 50 causes the DC

detect circuit 68 and the AC detect circuit 70 to be isolated from the tip-ring pair TRA and causes the TR reverse switch 64 to re-reverse the polarity of the tip-ring pair TR1.

5 In response to detecting the re-reversal of the polarity of the tip-ring pair TR1, the TC tester 2 adapts itself to convey control signals to the ERM 22 on the sleeve S1 of the line 24₁. The control signals on the sleeve S1 are detected by the sleeve current
10 detect/termination 44₁ which supplies to the controller 50 signals indicative thereof. In response to the signals from the sleeve current detect/termination 44₁, the controller 50 causes the relay 66 to adjust and connect the tip-ring pair TR1 of the line 24₁ to the tip-ring pair TRA.
15 Connecting the tip-ring pair TR1 of line 24₁ to the tip-ring pair TRA creates between the TC tester 2 and the selected telephone line a test path which includes the tip-ring pair TR1 of line 24₁, the tip-ring pair TRA and the tip-ring pair TR Bus.

20 Similarly, a control signal supplied to the ERM 22 by one of the RTC testers 20₁-20₃ on the tip lead of one of tip-ring pairs TR2-TR4 of lines 24₂-24₄ is detected by one of the current detectors 40₂-40₄, respectively. In response to detecting the control signal, the one of the current
25 detectors 40₂-40₄ supplies to the controller 50 a signal indicative thereof. In response to the signal from the one of the current detectors 40₂-40₄, the controller 50 causes the relays 60 and 72 to adjust and connect the one of the tip-ring pairs TR2-TR4 of the lines 24₂-24₄ to the MF
30 decoder 62 and the TR reverse switch 64. The controller 50 causes the TR reverse switch 64 to reverse the polarity of the one of the tip-ring pairs TR2-TR4 of the lines 24₂-24₄. In response to detecting the reversed polarity, the one of the RTC testers 20₁-20₃ supplies control signals on the one
35 of the tip-ring pairs TR2-TR4 of the lines 24₂-24₄. The MF decoder 62 converts the control signals into digital signals usable by the controller 50. The digital signals

from the MF decoder 62 are processed by the controller 50 into the address signals that are provided to the X-decoder 84 and the Y-decoder 86. The address signals cause the X-decoder 84 and the Y-decoder 86 to supply to the line matrix 80 the X-DEC signal and the Y-DEC signal. The digital signals from the MF decoder 62 also cause the controller 50 to adjust the relay 88 to connect the tip-ring pair TRB to the tip-ring pair TR Bus and cause the controller 50 to connect the DC detect circuit 76 and the AC detect circuit 78 to the tip-ring pair TRB.

The X-DEC signal and the Y-DEC signal received by the line matrix 80 cause one of the relay assemblies 80₁-80₅₀ to adjust and connect the tip-ring pair TR Bus to (i) a line-side 12 and a drop-side 8 of a selected telephone line in a bridge mode, (ii) the line-side 12 of the selected telephone line or (iii) the drop-side 8 of the selected telephone line. When connected in the bridge mode, the tip-ring pair TR Bus connects the line-side 12 and drop-side 8 of the selected customer telephone line to the DC detect circuit 76 and the AC detect circuit 78 via the tip-ring pair TRB. The DC detect circuit 76 and the AC detect circuit 78 detect the presence or absence of a respective DC voltage or an AC voltage, indicative of activity on the selected customer telephone line, and provide to the controller 50 outputs indicative thereof. In the absence of the DC detect circuit 76 or the AC detect circuit 78 detecting the respective DC voltage or AC voltage on the selected customer telephone line, the controller 50 causes the DC detect circuit 76 and the AC detect circuit 78 to be isolated from the tip-ring pair TRB and causes the TR reverse switch to re-reverse the polarity of the one of the tip-ring pairs TR2-TR4 of the lines 24₂-24₄.

In response to detecting the re-reversal of the polarity, the one of the RTC testers 20₁-20₃ adapts itself to convey control signals to the ERM 22 on one of the sleeves S2-S4 of the lines 24₂-24₄ corresponding to the one of the tip-ring pairs TR2-TR4 of lines 24₂-24₄. The control

signals on the one of the sleeves S2-S4 of the lines 24₂-24₄, are detected by one of the sleeve current detect/terminations 44₂-44₄, which supplies to the controller 50 signals indicative thereof. In response to the signals
5 from the one of the sleeve current detect/terminations 44₂-44₄, the controller 50 causes the relays 72 and 74 to adjust and connect the one of the tip-ring pairs TR2-TR4 of the lines 24₂-24₄ to the tip-ring pair TRB, thereby creating between the one of the RTC testers 20₁-20₃ and the selected
10 telephone line, a test path which includes the one of the tip-ring pairs TR2-TR4 of the lines 24₂-24₄, the tip-ring TRB and the tip-ring TR Bus.

Referring to Fig. 5, and with ongoing reference to Figs. 3 and 4a-4b, a pair of relay assemblies 82₁ and 82₂
15 are shown isolated from the line matrix 80. The relay assembly 82₁ includes a first double-pole double-throw relay 90₁ and a second double-pole double-throw relay 92₁. The control inputs of the relays 90₁ and 92₁ are energizable via the X-DEC signal and the Y-DEC signal supplied from the X-
20 decoder 84 and the Y-decoder 86, respectively. In a relaxed state, when the X-DEC signal and Y-DEC signal are not supplied to the control inputs of the relays 90₁ and 92₁, the drop-side 8₁ of the telephone line of the TC customer 6₁ is connected to the TC switch 4 through the
25 normally closed contacts of the relay 92₁ and the line-side 12₁ of the telephone line of the TC customer 6₁.

To detect the presence or absence of customer activity on the telephone line of the customer 6₁, the control inputs of the relay 90₁ are energized by the X-DEC
30 signal and the Y-DEC signal so that the contacts of the relay 90₁ are adjusted from the normally closed state to the normally open state. This adjustment connects the tip-ring pair TR Bus to the telephone line of the TC customer 6₁ in a bridge mode. When the telephone line of the TC customer
35 6₁ is connected to the tip-ring pair TR Bus in a bridge mode and the relay 88 is adjusted so that the tip-ring pair TRA are connected to the tip-ring pair TR Bus, the controller

50 causes the DC detect circuit 68 and AC detect circuit 70 to be connected to the tip-ring pair TRA to detect activity on the telephone line of the TC customer 6₁.

5 If activity is detected on the telephone line of the TC customer 6₁, the DC detect circuit 68 and/or the AC detect circuit 70 supply to the controller 50 a signal indicative thereof. In response to the signal indicative of customer activity on the telephone line of the TC customer 6₁, the controller 50 causes the relay 92₁ to
10 maintain the connection between the line-side 12₁ and the drop-side 8₁ of the telephone line of the TC customer 6₁. For simplicity of illustration, the line-side 12 and the drop-side 8 of each customer telephone line are illustrated as a single line. However, each customer telephone line
15 includes a tip-ring pair, e.g., TR₁, which are connectable to the tip-ring pair TR Bus via the line matrix 80.

If, however, no activity is detected on the telephone line of the TC customer 6₁, the DC detect circuit 68 and the AC detect circuit 70 do not supply signals to
20 the controller 50. In the absence of receiving signals from the DC detect circuit 68 and the AC detect circuit 70, the controller 50 causes the X-decoder 84 and the Y-decoder 86 to supply the X-DEC signal and Y-DEC signal to the control inputs of relays 90₁ and 92₁. These signals cause
25 the contacts of relays 90₁ and 92₁ to change state to connect the tip-ring pair TR Bus to the drop-side 8₁ of the telephone line of the TC customer 6₁ or the line-side 12₁ of the telephone line of the TC customer 6₁.

To connect the drop-side 8₁ of the telephone line
30 of the TC customer 6₁ to the tip-ring pair TR Bus, the controller 50 causes the X-decoder 84 and the Y-decoder 86 to supply to the relays 90₁ and 92₁ the X-DEC signal and the Y-DEC signal which cause the contacts of the relay 92₁ to adjust to the normally open state and the contacts of relay
35 90₁ to adjust to, or remain in, the normally closed state. When the contacts of relays 90₁ and 92₁ are adjusted to

these states, the tip-ring pair TR Bus is connected to the drop-side 8₁ of the telephone line of the TC customer 6₁.

To connect the line-side 12₁ of the telephone line of the TC customer 6₁ to the tip-ring pair TR Bus, the controller 50 causes the X-decoder 84 and the Y-decoder 86 to supply to the relays 90₁ and 92₁ the X-DEC signal and the Y-DEC signal which cause the contacts of relays 90₁ and 92₁ to adjust to the normally open state. When the contacts of relays 90₁ and 92₁ are adjusted to the normally open state, the tip-ring pair TR Bus is connected to the line-side 12₁ of the telephone line of the TC customer 6₁.

The relay assembly 82₂, shown in Fig. 5, operates in the same manner as the relay 82₁ described above. Specifically, the contacts of relays 90₂ and 92₂ of the relay assembly 82₂ are adjusted in response to the X-DEC signal and the Y-DEC signal supplied to the control inputs of the relays 90₂ and 92₂ to connect the tip-ring pair TR Bus to the drop-side 8₂ and/or the line-side 12₂ of the telephone line of the RTC₁ customer 6₂.

The relay assemblies 82₁ and 82₂ are representative of the relay assemblies 82₃-82₅₀ shown in block diagram form in Fig. 4b. In the embodiment shown in Fig. 5, the telephone line of the TC customer 6₁ is connected to the TC tester 2 via the TC switch 4 and the relay assembly 82₁. Moreover, the telephone line of the RTC₁ customer 6₂ is connected to the RTC₁ tester 20₁ via the RTC₁ switch 16₁, the IDF 18 and the relay assembly 82₂. The TC customer 6₁, however, can be connected to one of the RTC switches 16₁-16₃ by disconnecting the line-side 12₁ of the TC customer 6₁ from the TC switch 4 and connecting the line-side 12₁ to a port of the IDF 18 which is connected to the one of the RTC switches 16₁-16₃. Similarly, the RTC₁ customer 6₂ can be connected to the TC switch 4, the RTC₂ switch 16₂ or the RTC₃ switch 16₃, by disconnecting the line-side 12₂ from the port of the IDF 18 which connects the RTC₁ customer 6₂ to the RTC₁ switch 16₁, and connecting the line-side 12₂ to the TC switch 4 or a port of the IDF 18 which is

connected to the RTC₂ switch 16₂ or the RTC₃ switch 16₃. Other customer telephone lines can be connected to the TC switch 4 or one of the RTC switches 16₁-16₃ in a similar manner.

5 In the embodiment shown in Fig. 3, each of the TC switch 4 and the RTC switches 16₁-16₃ are shown servicing one customer 6₁ and 6₂-6₄, respectively, via the MDF 10 and the ERM 22. However, as shown in Fig. 6, a plurality of TC
10 customers 100 can be connected to the TC switch 4 via the line-sides 102 and the drop-sides 104 of a plurality of telephone lines of the TC customers 100. Similarly, a plurality of RTC₁ customers 110 can be connected to the RTC₁ switch 16₁ via the line-sides 112 and the drop-sides 114 of a plurality of telephone lines of the RTC₁ customers
15 110. Moreover, a plurality of RTC₂ customers 120 can be connected to the RTC₂ switch 16₂ via the line-sides 122 and the drop-sides 124 of a plurality of telephone lines of the RTC₂ customers, and a plurality of RTC₃ customers 130 can be connected to the RTC₃ switch 16₃ via the line-sides 132 and
20 the drop-sides 134 of a plurality of telephone lines of the RTC₃ customers.

The TC switch 4 enables each of the line-sides 102 connected thereto to be selectively connected to the TC
tester 2. For example, in response to a control signal
25 from the TC tester 2, the TC switch 4 connects the TC tester 2 to a selected one of the line-sides 102, e.g., line-side 12₁. Each RTC switch 16₁-16₃ enables each of the line-sides 112, 122 and 132 connected thereto to be selectively connected to one of the RTC testers 20₁-20₃.
30 For example, in response to a control signal from the RTC tester 20₁, the RTC₁ switch 16₁ connects the RTC₁ tester to a selected one of the line-sides 112, e.g., line-side 12₂.

When testing is complete, the one of the TC
tester 2 and the RTC testers 20₁-20₃ conducting a test
35 supplies to the ERM 22 via the corresponding sleeve S1-S4 of the lines 24₁-24₄ a test termination control signal. The sleeve current detect/termination 44₁-44₄ connected to the

sleeve S1-S4 of the lines 24₁-24₄ on which the test termination control signal is supplied converts this signal into a digital test termination control signal which is supplied to the controller 50. In response to receiving the digital test termination control signal, the controller 50 causes the X-decoder 84 and the Y-decoder 86 to withhold from the line matrix 80 the X-DEC signal and the Y-DEC signal. In the absence of the X-DEC signal and the Y-DEC signal, the relay assemblies 82₁-82₅₀ of the line matrix 80 adjust to their normally closed state thereby connecting together the line-side and the drop-side of each customer telephone line connected to the line matrix 80. The digital test termination control signal also causes the controller 50 to adjust the relays 66 and 74, as necessary, to isolate the tip-ring pair TRA from the tip-ring pair TR1 of line 24₁ or to isolate the tip-ring pair TRB from one of the tip-ring pairs TR2-TR4 of lines 24₂-24₄, respectively.

Based on the foregoing, it can be seen that the ERM 22 enables the TC tester 2 or the RTC testers 20₁-20₃ to test the drop-side 8 and/or the line-side 12 of any telephone line connected to the respective MDF 10 and/or the ERM 22. For security purposes, the controller 50 can be programmed to provide controlled access to telephone lines connected to the MDF 10 and/or the ERM 22. For example, the controller 50 can be programmed so that the RTC testers 20₁-20₃ access only the telephone lines of their respective customers. Moreover, the controller 50 can be programmed to restrict access to telephone lines connected to the TC switch 4 or one of the RTC switches 16₁-16₃.

The ERM 22 can include a plurality of line matrices 80 connected to the tip-ring pair TR Bus and the output of the X-decoder 84 and the Y-decoder 86. The decoding capability of the controller 50, the X-decoder 84 and the Y-decoder 86 determine how many relay assemblies 82 the ERM 22 includes. In a preferred embodiment, the ERM 22 includes four line matrices 80, having fifty relay

assemblies each, in a common housing that is connected to the MDF 10.

5 In the absence of being routed through a line matrix 80, the line-side and drop-side of a customer telephone line are connected together. When a line matrix 80 is installed, however, the line-side and/or drop-side of the customer telephone line are connected to a relay assembly 82 in the manner described above.

10 The invention has been described with reference to the preferred embodiment. Obvious modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come
15 within the scope of the appended claims or the equivalents thereof.

WE CLAIM:

1. A test system for testing a first plurality of telephone lines and a second plurality of telephone lines, with each telephone line having a line-side and a drop-side, the test system comprising:
 - 5 an electronic relay matrix (ERM) connectable between the line-side and the drop-side of each telephone line of the first plurality of telephone lines and connectable between the line-side and the drop-side of each telephone line of the second plurality of telephone lines;
 - 10 a first tester connectable to the ERM via the line-side of each of the first plurality of telephone lines and via a first test path; and
 - a second tester connected to the ERM via the line-side of each of the second plurality of telephone lines and via a second test path wherein, in response to a control signal on one of the first test path and the second test path, the ERM connects to the one of the first test path and the second test path at least one of the line-side and the drop-side of a telephone line of one of the first
 - 15 plurality of telephone lines and the second plurality of telephone lines.
2. The test system as set forth in claim 1, wherein:
 - in response to the control signal on the first test path, the ERM connects to the first test path at least
 - 5 one of the line-side and the drop-side of one of the telephone lines of the first plurality of telephone lines; and
 - in response to the control signal on the second test path, the ERM connects to the second test path at
 - 10 least one of the line-side and the drop-side of one of the telephone lines of the second plurality of telephone lines.
3. The test system as set forth in claim 1, wherein in the absence of the control signal, the ERM

connects together the line-side and the drop-side of each telephone line of the first plurality of telephone lines and connects together the line-side and the drop-side of each telephone line of the second plurality of telephone lines.

4. The test system as set forth in claim 1, wherein:

in response to the control signal on the first test path, the ERM connects to the first test path at least one of the line-side and the drop-side of one of the telephone lines of the second plurality of telephone lines; and

in response to the control signal on the second test path, the ERM connects to the second test path at least one of the line-side and the drop-side of one of the telephone lines of the first plurality of telephone lines.

5. The test system as set forth in claim 1, further including at least one of:

a first switch connected between the first tester and the line-sides of the first plurality of telephone lines, with the first switch configured to connect to the first tester the line-side of one of the first plurality of telephone lines; and

a second switch connected between the second tester and the line-sides of the second plurality of telephone lines, with the second switch configured to connect to the second tester the line-side of one of the second plurality of telephone lines.

6. The test system as set forth in claim 5, further including:

a third tester;

a third switch connected between the third tester and the ERM, with the third switch connected to the ERM via line-sides of a third plurality of telephone lines, and

, with the third switch configured to connect to the third tester at least one of the line-sides of the third plurality of telephone lines; and

an intermediate distribution frame connected
5 between the second switch and the ERM and between the third switch and the ERM, with the intermediate distribution frame configured to connect each line-side of the second plurality of telephone lines and each line-side of the third plurality of telephone lines to the second tester and
10 the third tester, respectively.

7. The test system as set forth in claim 1, further including a main distribution frame connected between the ERM and the drop-sides of the first plurality of telephone lines and between the ERM and the drop-sides
5 of the second plurality of telephone lines.

8. The test system as set forth in claim 1, wherein the ERM includes:

a line matrix having a plurality of relay assemblies, with each relay assembly configured to connect
5 together the line-side and the drop-side of a telephone line of one of the first plurality of telephone lines and the second plurality of telephone lines, and with each relay assembly having a control input configured to receive an address signal;

10 a relay mechanism connected between the line matrix and the first test path and between the line matrix and second test path; and

a controller configured to detect a control signal on one of the first test path and the second test
15 path, with the controller, in response to detecting the control signal, causing the relay mechanism to connect the one of the first test path and the second test path to the plurality of relay assemblies and causing an address signal to be generated to one of the relay assemblies whereby the
20 one relay assembly adjusts and connects the one of the

first test path and the second test path to at least one of the line-side and the drop-side of the telephone line connected to the one relay assembly.

9. An electronic relay matrix (ERM) connectable between a plurality of testers and a plurality of telephone lines, with each telephone line having a line-side and a drop-side, with each tester connectable to the ERM through
5 a test path and through the line-side of at least one of the plurality of telephone lines, the ERM comprising:

a line matrix including a plurality of relay assemblies, with each relay assembly configured to connect together the line-side and the drop-side of one of the
10 plurality of telephone lines, with each relay assembly configured to receive an address signal;

a relay mechanism connected between the line matrix and the test paths of the plurality of testers; and

a controller configured to detect a control
15 signal on one of the test paths, with the controller, in response to detecting the control signal, causing the relay mechanism to connect the one test path to the plurality of relay assemblies and causing an address signal to be generated whereby one of the relay assemblies adjusts and
20 connects the one test path to at least one of the line-side and the drop-side of the telephone line connected to the one relay assembly.

10. The ERM as set forth in claim 9, further including:

a plurality of current detectors, with each current detector configured to detect the presence of the
5 control signal on one of the test paths and to provide to the controller an indication thereof;

a multi-frequency (MF) decoder configured to decode a control signal on the one of the test paths and to provide to the controller the decoded control signal;

10 a TR reverse switch configured to receive a control signal from the controller and, in response to receiving the control signal, reverse a polarity of a tip-ring pair which comprise the one of the test paths;

 a DC detect circuit configured to detect a DC
15 signal on one of the plurality of telephone lines and to provide the controller with an indication thereof; and

 an AC detect circuit configured to detect an AC signal on one of the plurality of telephone lines and to provide the controller with an indication thereof.

11. The ERM as set forth in claim 10, wherein:
each test path includes a ring lead, a tip lead
and a sleeve lead; and

the plurality of current detectors include:

5 a first plurality of current detectors, each of which are configured to detect the control signal on one of the tip lead and the ring lead of one of the test paths and to provide to the controller an indication thereof; and

10 a second plurality of current detectors, each of which are configured to detect another control signal on the sleeve lead of one of the test paths and to provide to the controller an indication thereof.

12. The ERM as set forth in claim 10, wherein the relay mechanism includes:

5 a first relay connected between the MF decoder and the test paths, with the first relay configured to connect the MF decoder to the one test path in response to one of the plurality of current detectors detecting the control signal on the one test path;

 a second relay connected between the plurality of relay assemblies and at least one of the DC detect circuit
10 and the AC detect circuit, with the second relay configured to connect the at least one of the DC detect circuit and

the AC detect circuit to the plurality of relay assemblies in response to the controller receiving the decoded control signal; and

- 15 a third relay connected between the test paths and the plurality of relay assemblies, with the third relay configured to connect the one test path to the plurality of relay assemblies in response to the at least one of the DC detect circuit and the AC detect circuit detecting an
20 absence of a DC signal and an AC signal, respectively, on the telephone line connected to the at least one relay assembly.

13. The ERM as set forth in claim 9, further including an address decoder connected between the controller and the line matrix, with the address decoder configured to receive from the controller a signal that
5 causes the address decoder to supply to the one relay assembly the address signal.

14. A method of testing one of a plurality of telephone lines, with each telephone line having a line-side and a drop-side, with one end of the line-side and one end of the drop-side of each telephone line connected
5 together, with the other end of the drop-side of each telephone line connectable to telephony equipment of a subscriber, with the other end of the line-side of each telephone line connectable to one of a plurality of testers, and with each tester connected to a test path, the
10 method comprising the steps of:

(a) detecting an absence of subscriber activity on one of the plurality of telephone lines having its line-side connectable to one tester; and

- (b) in response to detecting the absence of
15 subscriber activity, connecting one of the test path of the one tester and the test path of another tester to at least one of the line-side and the drop-side of the one of the plurality of telephone lines.

15. The method as set forth in claim 14, further comprising the steps of:

opening the connection between the line-side and the drop-side of the one of the plurality of telephone
5 lines; and

connecting one of the test path of the one tester and the test path of the other tester to one of the line-side and the drop-side of the one of the plurality of telephone lines.

16. The method as set forth in claim 14, further comprising the steps of:

detecting a control signal on the test path of the one tester;

5 decoding the control signal; and

connecting the test path of the one tester to the at least one of the line-side and the drop-side of the one of the plurality of telephone lines.

17. The method as set forth in claim 14, further comprising the step of disconnecting one of the test path of the one tester and the test path of the other tester from the at least one of the line-side and the drop-side of
5 the one of the plurality of telephone lines.

18. The method as set forth in claim 14, further comprising the steps of:

detecting a control signal on the test path of the other tester;

5 decoding the control signal; and

connecting the test path of the other tester to the at least one of the line-side and the drop-side of the one of the plurality of telephone lines.

19. An apparatus for testing a telephone line, the apparatus comprising:

a controller;

a decoder connected to the controller and connectable to a test path, with the decoder configured to decode a control signal on the test path and to provide the decoded control signal to the controller;

5 a line matrix connected to the controller and connectable to a plurality of telephone lines, with each of the plurality of telephone lines having a line-side and a drop-side;

10 a telephone line detector connected to the controller and connectable to the plurality of the telephone lines; and

a relay mechanism connected to the controller, the line matrix, the telephone line detector and the test path of the first tester, wherein:

15 in response to receiving the decoded control signal, the controller causes the line matrix to select one of the plurality of telephone lines and causes the relay mechanism to connect the telephone line detector to the selected one of the plurality of telephone lines; and

20 in response to the telephone line detector detecting an absence of activity on the selected one of the plurality of telephone lines, the controller causes the relay mechanism to connect
25 the test path to at least one of the line-side and the drop-side of the selected one of the plurality of telephone lines.

20. The apparatus as set forth in claim 19, wherein the telephone line detector detects at least one of an AC signal and a DC signal on the selected one of the plurality of telephone lines.

1/6

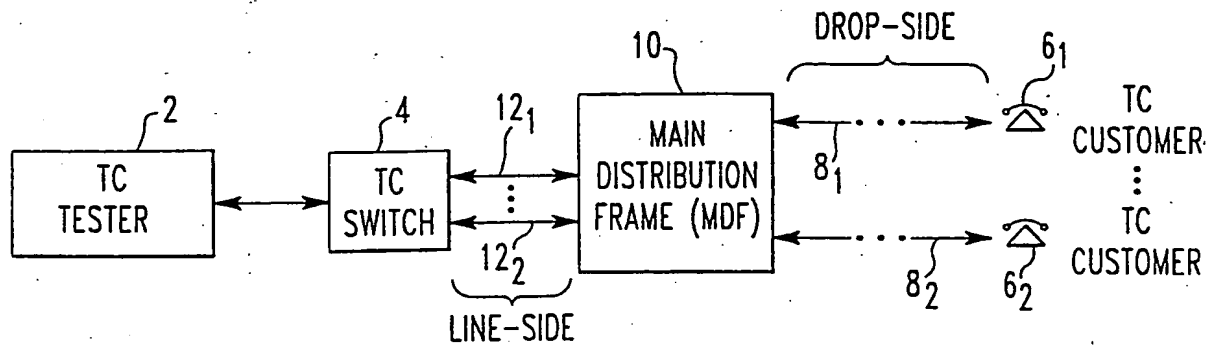


FIG. 1
(PRIOR ART)

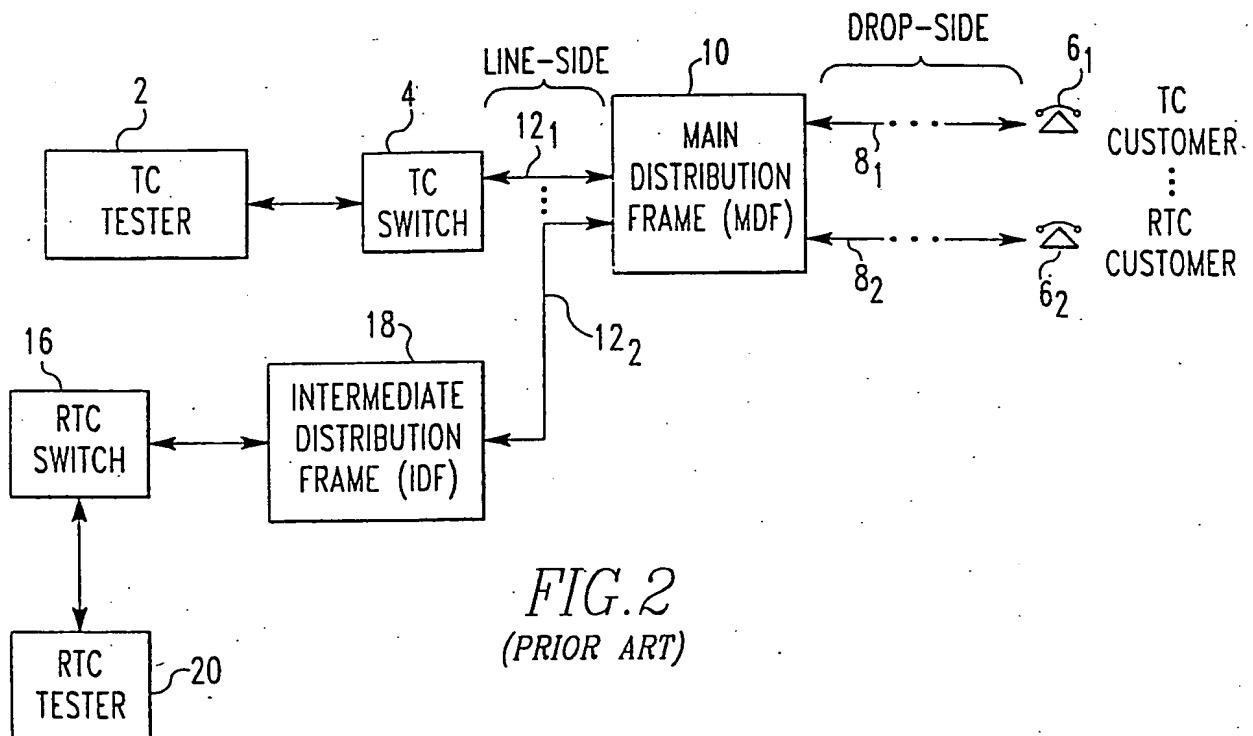
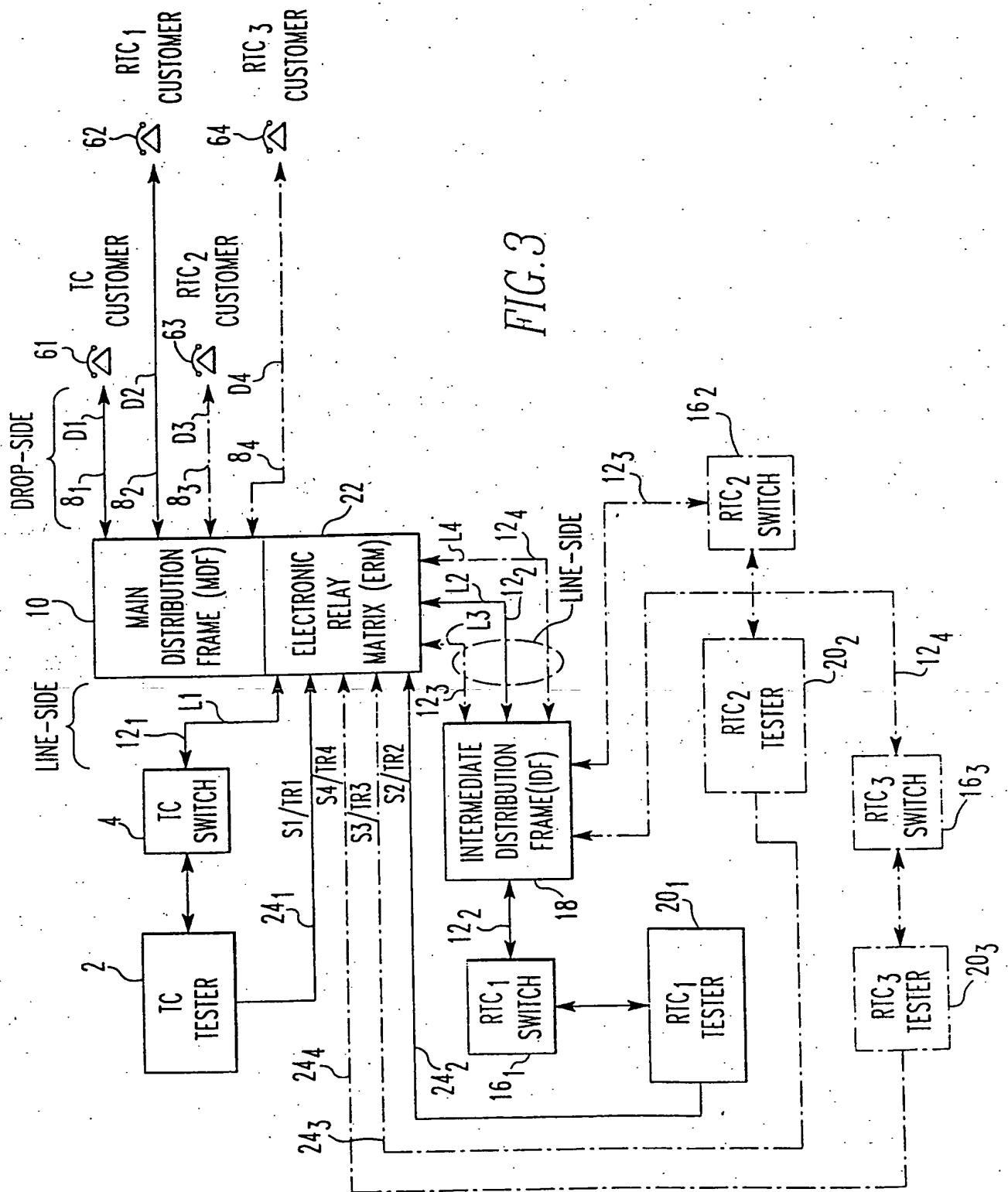
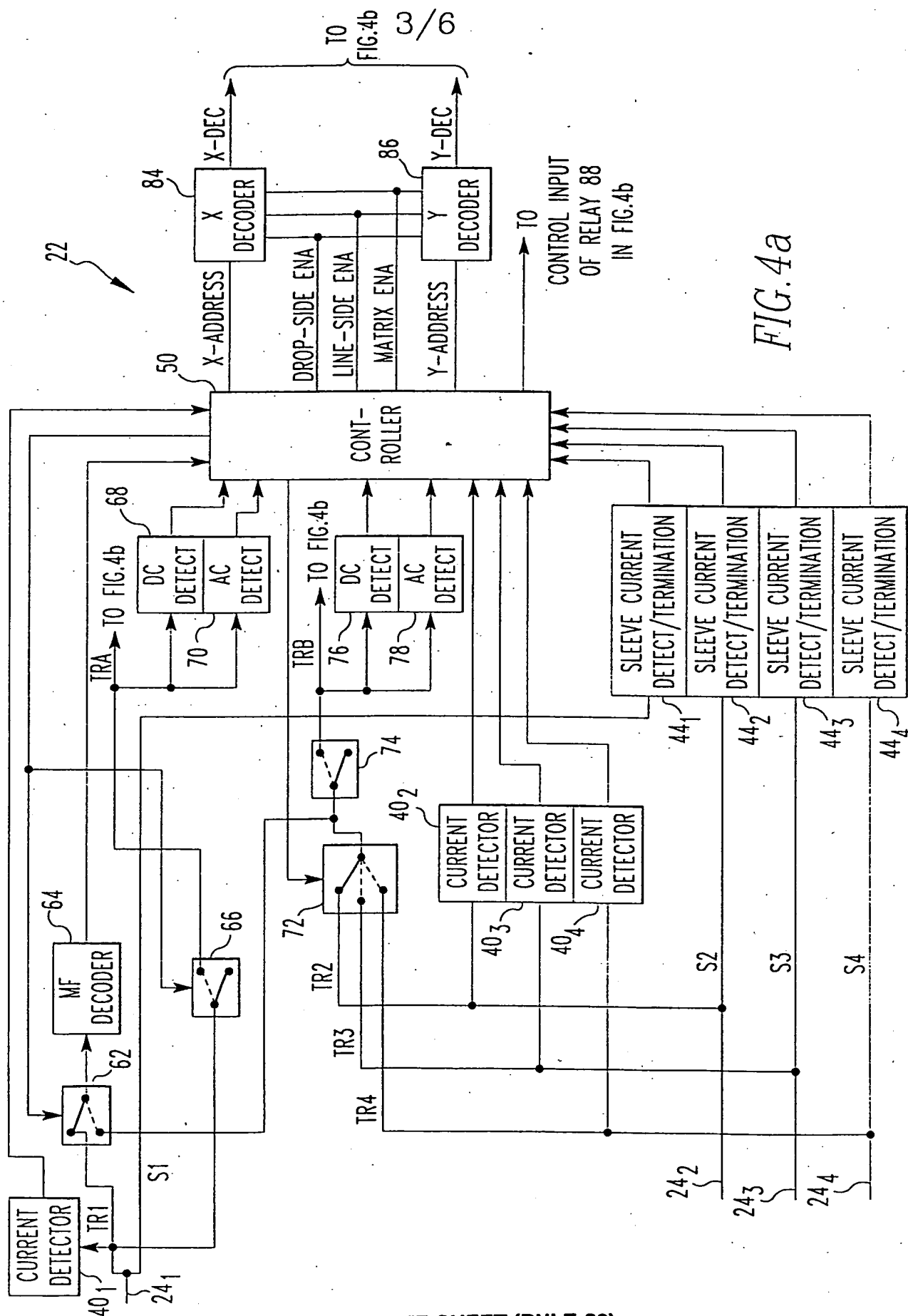


FIG. 2
(PRIOR ART)

2/6





4/6

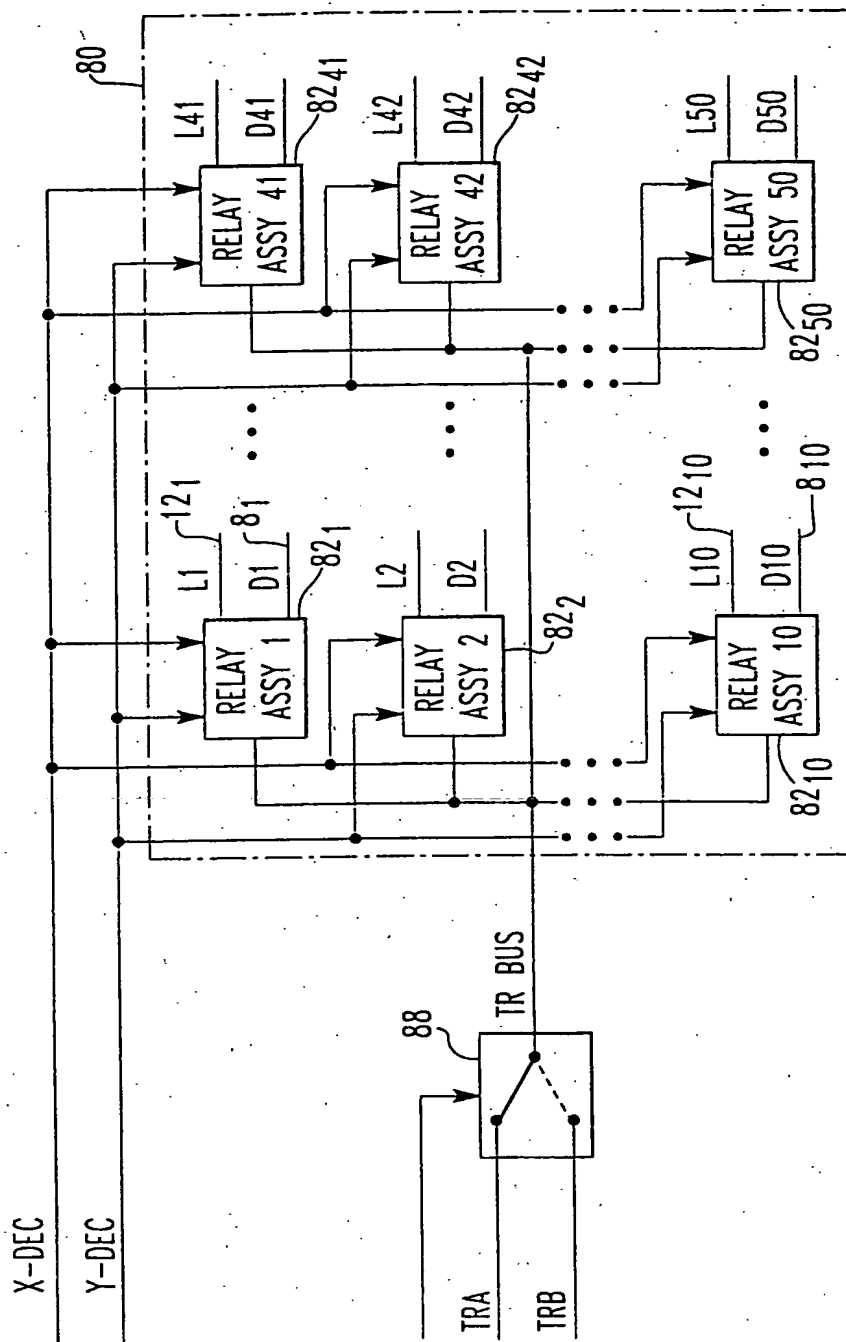


FIG. 4b

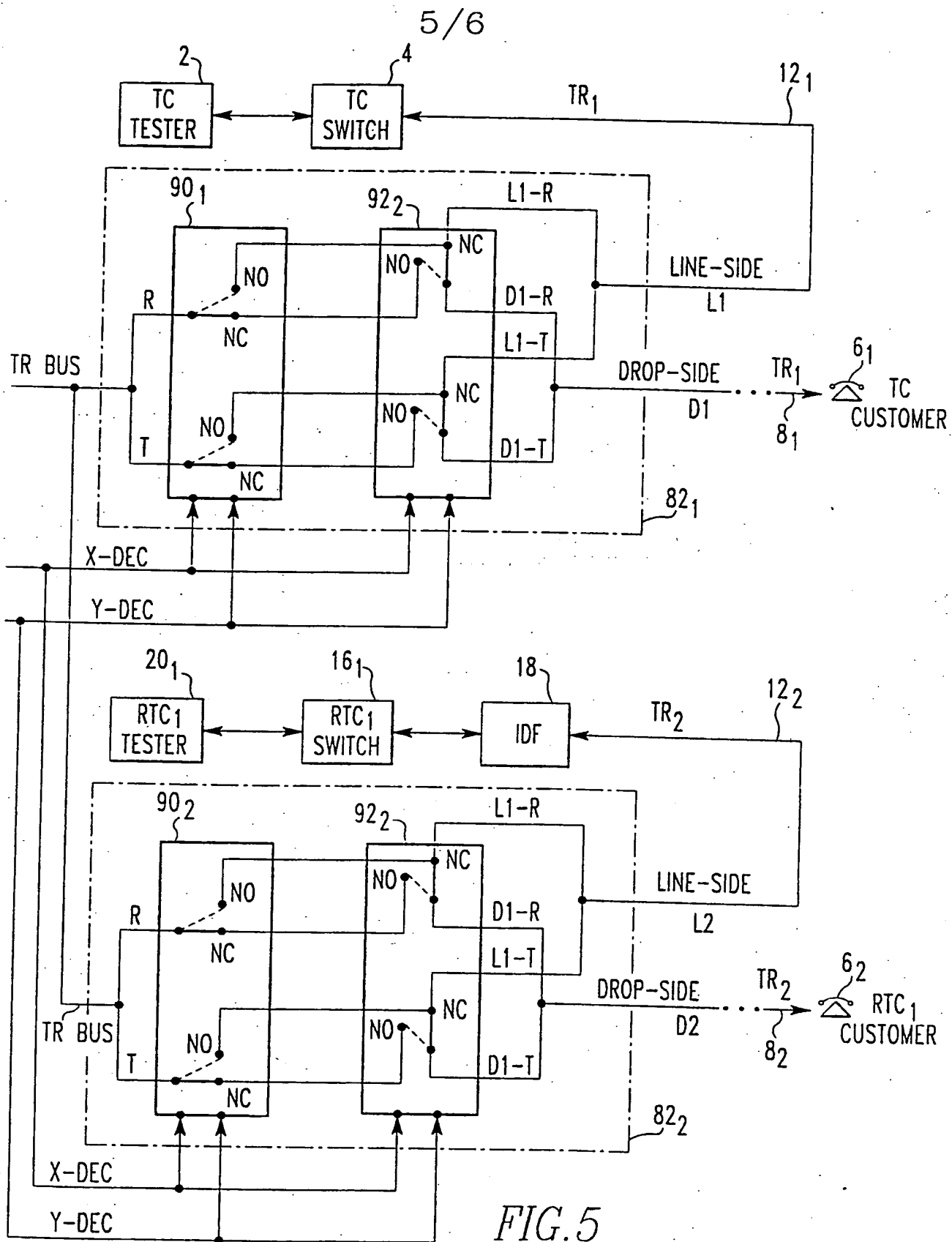


FIG. 5

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